doubtless a fortress formerly. Remains of utensils and human bones have also been found. According to Arabian sources the large city of Aphrosiab existed there in the time of Moses; it was the royal residence, and the king's castle stood on the hill, and was provided with subterranean corridors. The result of the excavations show that the ruins are indeed those of a very ancient city. The various depths, however, differ widely; in the lower ones fine glass objects are found, which are quite absent from the upper ones; the lowest layers contain remains of a very primitive nature, *i.e.* coarse implements of clay and flint. The excavations are being continued. News from Turkestan announces the discovery of another ancient city, Achsy, on the right bank of the Amu Darya. Remains of brick walls and other buildings are said to be visible in considerable numbers.

THE additions to the Zoological Society's Gardens during the past week include a Macaque Monkey (*Macacus cynomolgus* ♂) from India, presented by Mr. A. F. M. Smith; a Brown Capuchin (*Cebus fatuellus*) from Guiana, presented by Mr. G. S. Malet Barrow; a White-backed Piping Crow (*Gymnorhina leuconota*) from Australia, presented by Mr. F. Larkworthy; two Loggerhead Turtles (*Thalassochelys caouana*) from the Mediterranean, presented by Mr. Allan McGregor; a Common Chameleon (*Chameleon vulgaris*) from North Africa, presented by Mr. A. R. Rogers; a Horned Lizard (*Phrynosoma cornutum*) from Texas, presented by Capt. H. Mends; a Brown Mud Frog (*Pelobates fuscus*), European, presented by Mr. Claude Russell; a Sulphur-breasted Toucan (*Ramphastos carinatus*) from Mexico, a Macaque Monkey (*Macacus cynomolgus* ♂) from India, a Robben Island Snake (*Coronella phocarum*) from South Africa, deposited; a Collared Fruit Bat (*Cynonycteris collaris*), born in the Gardens.

OUR ASTRONOMICAL COLUMN

THE APPROACHING APPEARANCE OF ENCKE'S COMET.—It may be hoped that, as at the last return of this comet in 1881, an accurate ephemeris for its reappearance, which is now at hand, may be issued from the Imperial Observatory at Pulkowa. According to the mean motion, assigned by the calculations of Dr. Backlund at perihelion passage in 1881, the comet would be again in perihelion (perturbations neglected) about March 7·5 G.M.T., 1885, so that as the effect of planetary attraction will be small during the actual revolution, the comet's track in the heavens will not greatly differ from that it followed in 1852, when the perihelion passage occurred on March 14. It was first observed in that year by Dr. Vogel, at Mr. Bishop's Observatory in the Regent's Park on the evening of January 9, a refractor of 7 inches aperture being employed; at this time its distance from the sun was 1·35, and that from the earth 1·55, so that the intensity of light expressed in the usual manner was 0·23. At the return in 1875, when the perihelion passage took place on April 13, the comet was detected at the Observatory of Marseilles by M. Stephan, on the evening of January 27, distant from the sun 1·50, and from the earth 1·98, the theoretical intensity of light being therefore 0·113, or only half that at the comet's discovery in 1852. There appears to be a probability that with the large instruments now so comparatively common in observatories, the comet may be observed at a greater distance from the sun than in that year, and possibly during the absence of moonlight in November. If we assume March 7·5 for the date of perihelion passage, and bring up the longitudes in Dr. Backlund's orbit of 1881 to the beginning of 1885, we shall have the following positions of the comet at Greenwich midnight:—

1884	R.A. h. m.	N.P.D. ° ′	Distance from Earth	Distance from Sun	Intensity of Light
Nov. 5	23 2·1	82 24	1·310	2·043	0·140
9	22 57·4	83 4	1·318	2·000	0·144
13	22 53·4	83 40	1·328	1·957	0·148
17	22 50·1	84 13	1·340	1·913	0·152
21	22 47·4	84 42	1·352	1·867	0·157
25	22 45·4	85 7	1·365	1·821	0·162

Encke did not continue the ephemeris in 1852 beyond the date of perihelion passage, but if we calculate from his elements for April 19·5 (the day of the new moon), we find the comet's place to have been in R.A. 342° 55′, N.P.D. 109° 22′, its distance from the sun 0·89, and from the earth 0·95, or the intensity of light 1·41; it would rise at the Cape about 14h. 1m., and must therefore have been readily observable. We may expect that in 1885 observations will be made in the southern hemisphere after perihelion passage.

VARIABLE STARS.—Mira Ceti is now close upon a minimum, a phase of which there are not too many observations: its magnitude is usually about 8·5 on Bessel's scale. χ Cygni will probably be at minimum about November 15: the mean of the last five periods, according to the observations of the late Prof. Julius Schmidt, is 408·2 days, and 1880 May 31·2 may be taken as a mean maximum epoch. A maximum of the fiery-looking variable R Leonis may be expected about December 10. R Leporis will probably be at minimum at the beginning of January.

SOUTHERN BINARIES.—There are two southern double-stars which appear to deserve much closer observation than they have yet received on the score of their probable binary character and rapid motion. They are:—

	R.A. h. m. s.	N.P.D. ° ′
h. 5014	17 59 22	133 24·2
h. 5114	19 18 32	144 33·2

The positions are brought up to 1885·0 from the Paramatta Catalogue.

ON THE SEAT OF THE ELECTROMOTIVE FORCES IN THE VOLTAIC CELL

AT the Montreal meeting of the British Association a discussion on the above subject was opened by Prof. O. J. Lodge. Copies of the following notes were distributed to the members present by the opener of the discussion, together with the accompanying letter. As it has been suggested that their reproduction here would be of service, we willingly give them a place.

University College, Liverpool, July 29th, 1884

The following set of statements are privately issued by me solely with the object of securing attention to definite points in the discussion on Contact Electricity, at Montreal, which I have been instructed by the Sub-Committee to open. They are numbered for convenience of reference. I have no authority whatever for appending the names I have appended to some of the statements; and in general the whole thing is merely a statement of my own personal belief. At the same time the wording is carefully chosen and is intended to be correct in detail, and the views indicated I have held with greater or less clearness for some seven years. I should have small hesitation in believing these views to be true, were it not that I fear they are at variance with those of Sir Wm. Thomson. It is in no spirit of presumption, but simply in order more easily and distinctly to elicit the truth, that I have ventured thus to record them, and I am very willing to modify all or any of them on ground shown. It may be hoped that the discussion at Montreal will result in a substantial basis of agreement with regard to this elementary and long-debated matter. OLIVER J. LODGE

I.—ORTHODOX STATEMENTS BELIEVED BY O. J. L. TO BE TRUE IN THE FORM HERE SET DOWN

A.—Volta

1. Two metals in contact ordinarily acquire opposite charges; for instance, clean zinc receives a positive charge by contact with copper, of such a magnitude as would be otherwise produced under the same circumstances by an E.M.F. of ·8 volt.

2. This apparent contact E.M.F. or "Volta force" is independent of all other *metallic* contacts wheresoever arranged, hence the metals can be arranged in a numerical series such that the "contact force" of any two is equal to the difference of the numbers attached to them, whether the contact be direct or through intermediate metals. But whether this series changes when the atmosphere, or medium surrounding the metal, changes is an open question: on the one side are experiments of De la Rive, Brown, Schultze-Berge; on the other side, of Pfaff, Pellat, von Zahn. It certainly changes when the free metallic surfaces are oxidised or otherwise dirty. And in general

this "Volta force" is very dependent on all non-metallic contacts.

3. In a closed chain of any substances, the resultant E.M.F. is the algebraic sum of the Volta forces measured electrostatically in air for every junction in the chain; neglecting magnetic or impressed E.M.F. [Verified most completely by Ayrton and Perry.]

B.—Thomson

4. The E.M.F. in any closed circuit is equal to the energy conferred on unit electricity as it flows round it.

[Neglect magnetic or impressed E.M.F. in what follows.]

5. At the junction of two metals any energy conferred on, or withdrawn from, the current, must be in the form of heat. At the junction of any substance with an electrolyte, energy may be conveyed to or from the current at the expense of chemical action as well as of heat.

6. In a circuit of uniform temperature, if metallic, the sum of the E.M.F. is zero by the second law of thermodynamics; if partly electrolytic, the sum of the E.M.F. is equal to the sum of the energies of chemical action going on per unit current per second.

7. In any closed conducting circuit the total intrinsic E.M F. is equal to the sum of the chemical actions going on per unit electricity conveyed ($\Sigma . /\theta\epsilon$), diminished by the energy expended in algebraically generating reversible heat.

8. The locality of any E.M.F. may be detected, and its amount measured, by observing the reversible heat or other form of energy there produced or absorbed per unit current per second. [This is held by Maxwell, but possibly not by Thomson, though its establishment is due to him.]

II.—Statements believed by O. J. L. to be false though orthodox

9. Two metals in air or water or dilute acid, but not in contact, are practically at the same potential. [Sir Wm. Thomson, Clifton, Pellat.]

10. Two metals in contact are at seriously different potentials (*i.e.* differences of potential greater than such milli-volts as are concerned in thermo-electricity). [This is held by nearly everybody.]

11. The contact force between a metal and a dielectric, or between a metal and an electrolyte, is small. [Ayrton and Perry, Clifton, Pellat, and probably Sir Wm. Thomson].

III.—Statements believed by O. J. L. to be true though not orthodox

12. A substance immersed in any medium tending to act upon it chemically will (unless it is actually attacked) be at a different potential to the medium in contact with it, positive if the active element in the medium is electro-positive, negative if the active element is electro-negative.

13. The above difference of potential can be calculated approximately from the potential energy of combination between the substance and the medium, the energy being measured by compelling the combination to occur and observing the heat produced per amount of substance corresponding to one unit of electricity.

14. In addition to this contact force, due to potential chemical action or chemical strain, there is another which is independent of chemical properties, but which seems to be greatest for badly-conducting solids, and which is in every case superposed upon the former contact force, the two being observed together and called the Volta effect. Very little is known about this latter force except in the case of metals; and in these it varies with temperature, and is small. In the case of non-metals it is often much larger than the chemical contact force.

15. The total contact force at any junction can be experimentally determined by measuring the reversible energy developed or absorbed there per unit quantity of electricity conveyed across the junction. [Practical difficulties, caused by irreversible disturbances, being supposed overcome.]

16. In a chain of any substances whatever, the resultant E.M.F. between any two points is equal to the sum of the true contact forces acting across every section of the chain between the given points (neglecting magnetic or impressed forces).

17. In a closed chain the sum of the "Volta forces," measured electrostatically in any (the same) medium, is equal to the sum of the true contact forces, whether each individual Volta force be equal to each individual true force or not.

18. Wherever a current flows across a seat of E.M.F., there it must gain or lose energy at a rate numerically equal to the E.M.F. multiplied by the strength of the current.

Development of the above and Special Application to Metals.

19. A metal is not at the potential of the air touching it, but is always slightly below that potential by an amount roughly proportional to its heat of combustion, and calculable, at any rate approximately, from it. For instance, clean zinc is probably about 1·8 volts below the air, copper about ·8 volts below, and so on. If an ordinary oxidising medium be substituted for "air" in the above statement it makes but little difference.

20. Two metals put into contact reduce each other instantly to practically the same potential, and consequently the most oxidisable one receives from the other a positive charge, the effect of which can be observed electrostatically.

21. There is a slight true contact force at the junction of two metals which prevents their reduction to *exactly* the same potential, but the outstanding difference is small, and varies with temperature. It can be measured thermo-electrically by the Peltier effect, but in no other known way. It is probably entirely independent of surrounding media, metallic or otherwise.

22. If two metals are in contact the potential of the medium surrounding them is no longer uniform: if a dielectric it is in a state of strain, if an electrolyte it conveys a current.

23. In the former case the major part of the total difference of potential is related closely to the difference of the potential energies of combination, and is approximately calculable therefrom. In the latter case the total E.M.F. is calculable accurately from the energy of the chemical process going on, minus or plus the energies concerned in reversible heat effects.

24. There are two distinct and independent kinds of series in which the metals (and possibly all solids) can be placed; one kind depends on the dielectric or electrolytic medium in which the bodies are immersed; the other kind depends on temperature. The one is something like the Volta series, but it is really the Volta series minus the Peltier; the other is the Peltier. To reckon up the total E.M.F. of a circuit we may take differences of numbers from each series and add them together.

IV.—Brief Summary of the Argument

25. Wherever a current gains or loses energy, *there* must be a seat of E.M.F.; and conversely, wherever there is a seat of E.M.F., a current must lose or gain energy (that is, must generate or destroy some other form of energy, chemical, thermal, or other) in passing it.

26. A current gains no energy (*i.e.* destroys no heat) in crossing from copper to zinc, hence there is no appreciable E.M.F. there.

27. When a current flows from zinc to acid, the energy of the combination which occurs is by no means accounted for by the heat there generated, and the balance is gained by the current; hence at a zinc-acid junction there must be a considerable E.M.F. (say at a maximum 2·3 volts).

28. A piece of zinc immersed in acid is therefore at a lower potential than the acid, though how much lower it is impossible to say, because no actual chemical action occurs. [If chemical action does occur, it is due to impurities, or at any rate to local currents, and it is of the nature of a disturbance.]

29. A piece of zinc, half in air and half in water or acid, causes no great difference of potential between the air and the water (Thomson, Clifton, Ayrton and Perry, &c.), consequently air must behave much like water.

30. If the air were slightly positive to the water, as it is (Hankel), it might mean that the potential energy of combination of air with zinc is slightly greater than that of water, or it might represent a difference in the thermo-electric contact forces between zinc and air, and zinc and water, or it might depend on a contact force between air and water. [If such a contact force between air and water exists, it is obviously of great importance in the theory of atmospheric electricity, for the slow sinking of mist globules through the air would render them electrical.]

31. Condenser methods of investigating contact force no more avoid the necessity for unknown contacts than do straightforward electrometer or galvanometer methods; the circuit is completed by air in the one case and by metal in the other, and the E.M.F. of an air contact is more hopelessly unknown than that of a metal contact.

32. All electrostatic determinations of contact force are really determinations of the sum of at least three such forces, none of which are knowable separately by this means.

33. The only direct way of investigating contact force is by the Peltier effect or its analogues. [Maxwell.]

34. Zinc and copper in contact are oppositely charged, but are not at very different potentials: they were at different potentials before contact, but the contact has nearly equalised them.

[Certain portions of these statements which may appear wildly hypothetical, such as 13, are to be justified by figures. The justification is not complete, for lead and iron are untractable, but it does not affect the main position.]

THE AMERICAN ASSOCIATION

WE are indebted to the courtesy of the Editor of *Science* for the following reports of the Sectional proceedings of the American Association.

In the Section of Physics a paper was read on "The Relation of the Yard to the Metre," by Prof. William A. Rogers, who has given his life to perfecting the construction and the testing of standards of length, and the result of this his latest investigation is that the metre is 39·37027 inches in length. One of the most important physical measurements is that of the wave-length of light of any given degree of refrangibility, and this determination is best made by means of the diffraction grating. On account of the extensive use of the magnificent gratings constructed by Prof. Rowland for this purpose, Prof. Rogers instituted an investigation to determine the coefficient of expansion of the speculum-metal used in the construction of these gratings. He also noted that from its homogeneity, fineness of grain, and non-liability to tarnish, this speculum-metal is peculiarly suitable for constructing fine scales, though its extreme brittleness is an objection to its use for large scales.

Prof. Rowland stated that he proposed to construct scales on his ruling-engine which would enable the physicist at any time, by purely optical means, and without knowing the coefficient of expansion of the metal or its temperature, to obtain the value of the length of the scale in terms of the wave-length of any given ray of light. These scales were simply to be straight pieces of speculum-metal ruled with lines just as an ordinary grating, except that the length of the lines is to be only about one centimetre, every one-hundreth line being somewhat longer than its neighbours: the whole ruled slip is to be one decimetre in length. From the manner of ruling, it will be easy to count the whole number of lines in the length of the strip, and then by a simple use of the scale as a grating, in a suitable spectrometer, the whole length may be immediately found at any time in terms of any specified wave-length of light. In some forms of telephones and in the microphone the action depends on the change in resistance of a small carbon button on being subjected to pressure. There has been much discussion as to whether this diminution of the resistance with pressure is due to a change in the resistance of the carbon itself, or simply to the better contact made between the carbon and the metallic conductor when the pressure is applied.

Prof. Mendenhall has carried out some experiments to determine the question; and one of his methods of experimenting—that with the hard carbons—appears to point conclusively in favour of the theory that the resistance of the carbon itself is altered by pressure. The experiments made by him on soft carbon are open to criticism, though they also point to the change taking place *in* the carbon. Prof. Mendenhall finds that the resistance is not simply proportional to the pressure, and thinks that by increasing the pressure a point of maximum conductivity would be reached where there would be no change in resistance for a small change in pressure.

Prof. A. Graham Bell, the inventor of the telephone, read a paper giving a possible method of communication between ships at sea. The simple experiment that illustrates the method which he proposed is as follows:—Take a basin of water, introduce into it, at two widely-separated points, the two terminals of a battery circuit which contains an interruptor, making and breaking the circuit very rapidly. Now at two other points touch the water with the terminals of a circuit containing a telephone. A sound will be heard, except when the two telephone terminals touch the water at points where the potential is the same. In this way the equipotential lines can easily be picked out. Now, to apply this to the case of a ship at sea: Suppose one ship to be provided with a dynamo-machine generating a powerful current, and let one terminal enter the water at the prow of the ship, and the other be carefully insulated, except at its end, and be trailed behind the ship, making connection with the sea at a considerable distance from the vessel; and suppose the current be rapidly made and broken by an interruptor; then the observer on a second vessel provided with similar terminal conductors to the first, but having a telephone instead of a dynamo, will be able to detect the presence of the other vessel even at a considerable distance; and by suitable modifications the direction of the other vessel may be found. This conception Prof. Bell has actually tried on the Potomac River with two small boats, and found that at a mile and a quarter, the farthest distance experimented upon, the sound due to the action of the interruptor in one boat was distinctly audible in the other. The experiment did not succeed quite so well in salt water.

Prof. Trowbridge then mentioned a method which he had suggested some years ago for telegraphing across the ocean without a cable; the method having been suggested more for its interest than with any idea of its ever being put in practice. A conductor is supposed to be laid from Labrador to Patagonia, ending in the ocean at those points, and passing through New York, where a dynamo-machine is supposed to be included in the circuit. In Europe a line is to extend from the north of Scotland to the south of Spain, making connection with the ocean at those points; and in this circuit is to be included a sensitive galvanometer. Then any change in the current in the American line would produce a corresponding change in current in the European line; and thus signals could be transmitted.

Mr. W. H. Preece then gave an account of how such a system had actually been put into practice in telegraphing between the Isle of Wight and Southampton during a suspension in the action of the regular cable communication. The instruments used were a telephone in one circuit, and in the other about twenty-five Leclanché cells and an interruptor. The sound could then be heard distinctly; and so communication was kept up until the cable was again in working order. Of the two lines used in this case, one extended from the sea at the end of the island near Hurst Castle, through the length of the island, and entered the sea again at Ryde; while the line on the mainland ran from Hurst Castle, where it was connected with the sea, through Southampton to Portsmouth, where it again entered the sea. The distance between the two terminals at Hurst Castle was about one mile, while that between the terminals at Portsmouth and Ryde amounted to six miles.

A few years ago Mr. E. H. Hall, then a student at the Johns Hopkins University, taking a thin strip of gold-leaf through which a current of electricity was passing, and joining the two terminals of a very sensitive galvanometer to two points in the gold-leaf, one on one edge, and the other on the other, choosing the points so exactly opposite that there was no current through the galvanometer, found that on placing the poles of a powerful electro-magnet, one above and the other below the strip of gold-leaf, he obtained a current through the galvanometer, thus indicating that there was a change in the electric potential, due to the action of the magnet. Mr. Hall explains this change by supposing the rotation of the equipotential lines in the conductor about the lines of magnetic force. This explanation has been brought into question by Mr. Shelford Bidwell, who attempts to explain the action thus: the magnetic force acting on the conductor carrying the current would cause the conductor to be moved sideways, were it free to move; but, since it is held by clamps at the ends, the magnetic force acting upon it brings it into a state of strain, one edge being compressed and the other stretched; and Mr. Bidwell supposes the whole Hall effect to be due to thermal actions taking place in consequence of this unsymmetrical state of strain. Prof. Hall, who is now at Harvard, has made some careful experiments to test this explanation of Mr. Bidwell. He used not only gold-leaf, but strips of steel, tinfoil, and other metals, and clamped them sometimes at both ends, sometimes in the middle, and sometimes only at one end; and in all cases the action was the same, with the same metal, irrespective of the manner of clamping. This was strong evidence against Mr. Bidwell's position.

Sir William Thomson suggested, as a further test to bring about the state of strain, which Mr. Bidwell supposes to be the primary cause of the action, by purely mechanical means, bring-